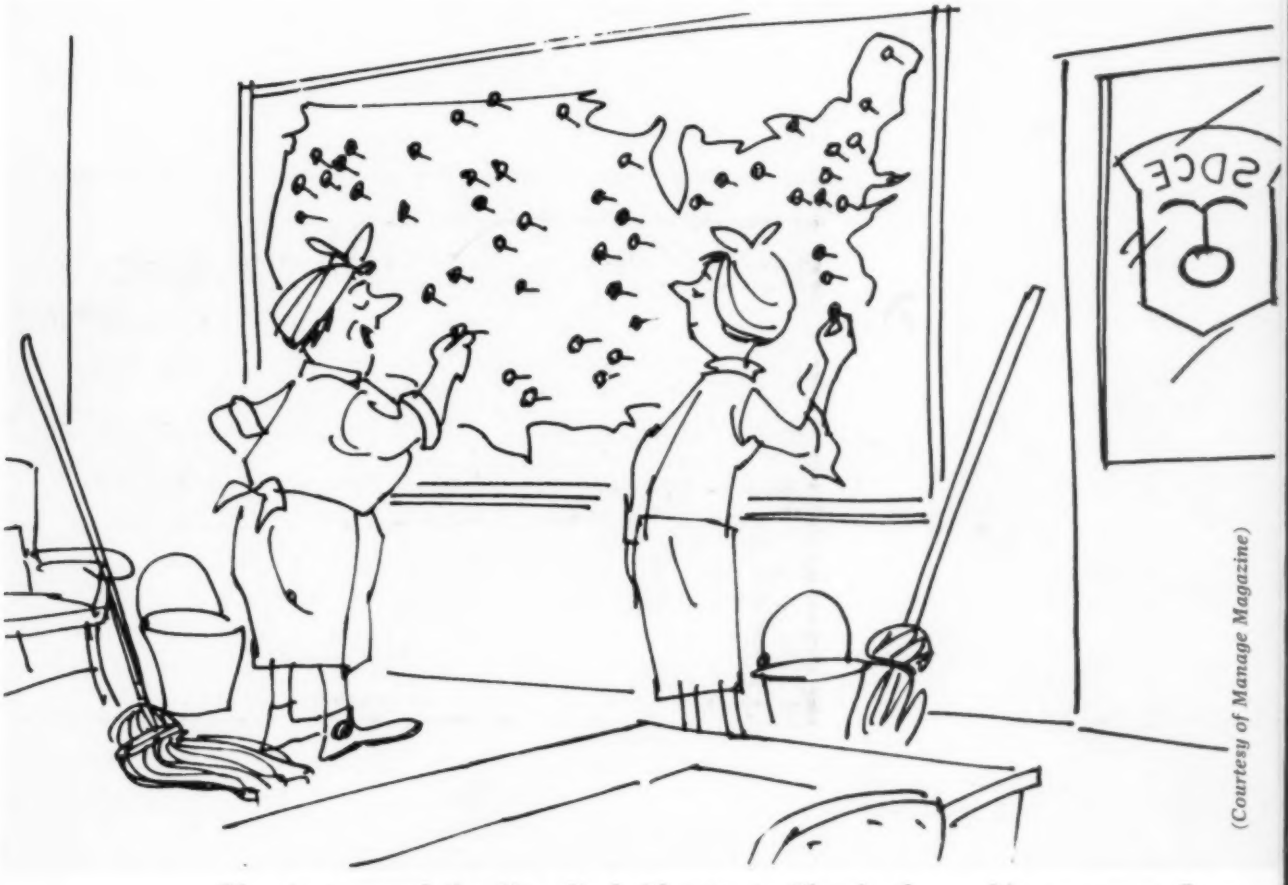
DIE CASTING ENGINEER

PUBLICATION OF THE SOCIETY OF DIE CASTING ENGINEERS / MAY 1961



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IN THIS ISSUE

THE INFLUENCE OF GAS CONTENT, PRESSURE AND MAGNESIUM CONTENT ON THE MECHANICAL PROPERTIES OF ALUMINUM DIE CASTINGS

ALLOY CONTROL FOR ZINC DIE CASTINGS

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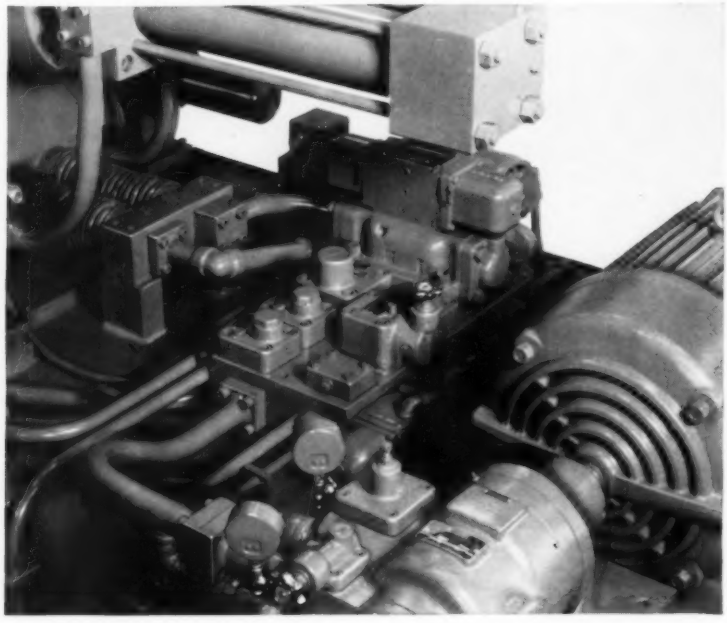

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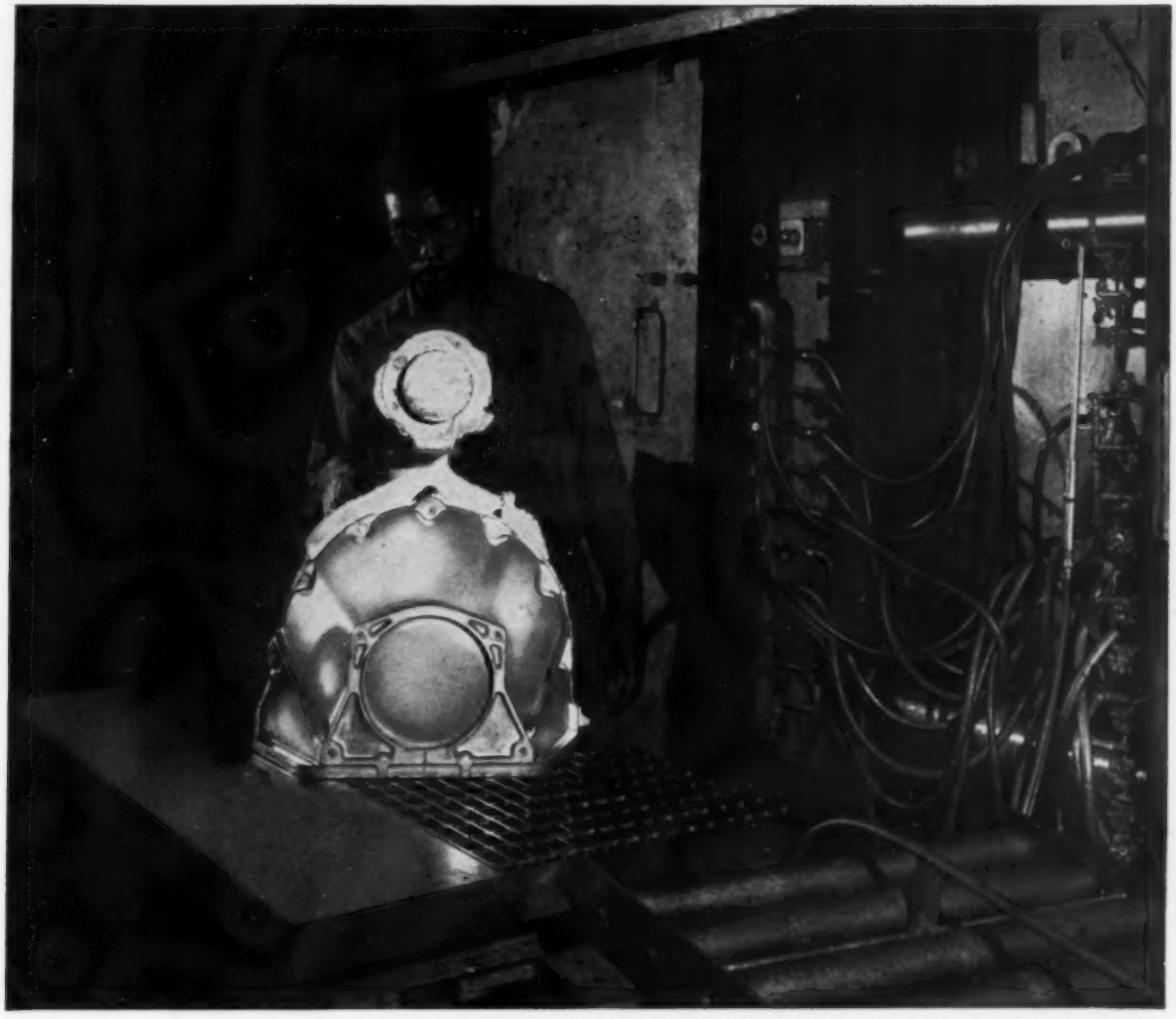

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PRESIDENT'S REPORT:

John L. MacLaren

ROLE OF *The Society of Die Casting Engineers* IN AMERICAN INDUSTRY

BEFORE THE beginning of the current decade, economists and businessmen propounded a slogan—"the Soaring Sixties." While the Sixties, generally speaking, haven't exactly begun soaring yet, there is very little doubt that they will. This will mean greatly increased production of a tremendous variety of products, many of which are now only in the planning stages. The expected population explosion and upgraded living standard will put a huge burden on the industrial machine to maintain output at adequate levels. Rapid technological progress in all fields of industrial endeavor will be mandatory.

How do organizations such as the American Zinc Institute and the Society of Die Casting Engineers fit into the picture? What should be done to facilitate the realization of the production potential implicit in the slogan "the Soaring Sixties"?

I would like first to develop the forward thinking of the Society of Die Casting Engineers, relating some of the pertinent background details of both the industry and the Society. Then, if you will forgive the presumption, I will dwell briefly on some of the ideas expressed by zinc die casting members of the Society on how the zinc industry might do its part.

INDUSTRY BACKGROUND

The die casting industry is over 60 years old in this country. However, its greatest growth has been realized in the past 10 years when 80 per cent of the production units now in operation were installed. A recent count shows approximately 10,600 die casting machines in use, 6,000 on zinc and 4,600 on aluminum. In the period 1952 to 1959 alone, total tonnage output of die castings increased 74 per cent, about double the rate of growth of Gross National Product.

This phenomenal activity in the die casting business is directly attributable to the rapid advances during the same period in the costs of skilled labor and concurrent lag in per hour productivity. These factors forced manufacturers to seek production methods requiring a minimum amount of direct labor. Die casting, in the case of metal parts, was the logical choice.

While the conditions responsible for the quick advancement of the die casting industry during the 1950s will undoubtedly continue to prevail during the 1960s, die casting has attained a degree of maturity which will penalize its past rate of growth unless something is done about it. A large part of the "cream" has been skimmed off the market for die castings—the industry will find it necessary to abandon complacency and exert special effort if the challenge of the '60s is to be met and the growth rate of the '50s approached.

The die caster will have to learn how to make castings better and cheaper. The metal man will have to provide superior materials more able to compete with substitutes. Both will have to get out and really sell the die cast product in every possible market, even those markets which hitherto had seemed to have marginal appeal. If these measures are aggressively pursued, there is absolutely no reason why the dynamism exhibited by the die casting industry in the past decade cannot be maintained in the present decade.

SDCE BACKGROUND

Six and a half years ago a small but bold and imaginative group of die casters met in Detroit to discuss ways and means of organizing their industry to help itself do a better job. Out of this meeting grew the Society of Die Casting Engineers, with the objective of

(*Continued on Page 8*)

Editor's Note: This talk was delivered by the President of SDCE at the May 1 annual meeting of the American Zinc Institute in Chicago. It is reproduced here as it develops the Society's present and planned future position in relation to the die casting industry.

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PRESIDENT'S REPORT
(Continued from Page 4)

promoting aggressively the dissemination of knowledge of the arts and sciences relating to die casting to die casters throughout the U.S.A. Then, as now, the purpose was to perform a technical service for individual members, without conflicting with any of the existing trade organizations having an interest in the die casting industry.

In July 1955 the Society received a charter from the State of Michigan. Three months later the first chapter, located in Detroit, was organized. Since then, chapters have been established in nine other die casting centers and membership has grown to well over one thousand persons. Forty per cent of this membership growth has occurred in the last 16 months.

Members of the Society are served in a number of ways, the most important of which is the monthly schedule of technical meetings at the chapter level. There the member is exposed to a thought-provoking presentation by a specialist on some pertinent technical subject. If he wishes, he may participate in the question and answer session. The meeting also provides a forum for testing his ideas, and an opportunity to compare problems with other die casters and suppliers in a friendly, informal atmosphere which encourages frank discussion.

Last year the Society sponsored and presented the first National Die Casting Exposition and Congress. Provision was made for interesting and informative exhibits by suppliers to the industry and prominent die casters as well as a comprehensive program of technical papers on the most talk-about subjects. Maximum educational value was sought in arranging the exhibits and papers and, as you may have heard, the affair was outstandingly successful in fulfilling this objective.

Since March 1957 the Society has been publishing its official magazine, the *Die Casting Engineer*. In 1960 the publication period was stepped up from quarterly to bi-monthly to permit the printing of an increased number of technical articles and so advance the dissemination of new ideas and knowledge of die casting subjects.

The Society has been very active in the past three years in establishing equipment standards that have been badly needed for reasons of performance and economy. One of the really important contributions of the Standards Committee has been the strain gage method of measuring the maximum locking tonnage of a die casting machine. This technique, which has been adopted uniformly by equipment manufacturers, has removed for the die caster much of the mystery introduced earlier by the claims of competing machine salesmen.

Another noteworthy activity of the Society was organized attendance by a large group of members at the Third International Pressure Die Casting Conference held in May 1960 at Stresa, Italy. The venture, which also included visits to over 20 die casting shops in five different European countries, marked an important "first" for the Society in bringing die casters from both sides of the ocean together to exchange technical knowledge. Partly as the result of this contact there were large delegations from overseas countries at the Die Casting Show held in Detroit six months later.

FUTURE PLANS OF SDCE

Although the Society has accomplished a great deal in its short history, the demands of the '60s will call for achievements that will far overshadow the record to date. Fortunately, the efforts of the dedicated people who nursed the Society to its present strong position have captured the imagination of die casters everywhere. Our present challenge is to harness this interest and focus it on the problems of the future.

The only limiting factor in the further growth of the die casting industry is the knowledge available to the caster, his supplier and his customer. If the ideal situation could be reached wherein each of these three groups possessed *all* the knowledge currently available, then the industry could forge ahead unimpeded. Unfortunately, in a young and highly competitive industry there is an understandable fear of divulging hard-earned knowledge that might be of value to a competitor. What the die caster doesn't fully appreciate is the worth to him of a system of free *exchange* of information and ideas. He could find that his own jealousy safeguarded techniques had been considerably improved upon by another shop. He could volunteer assistance to other die casters, receiving valuable advice from them in return.

While the Society cannot suddenly cause an "ideal situation" to develop, it can and will work diligently towards that end, encouraging the communication of knowledge by every feasible method.

As the heart of technical interchange is the chapter meeting, the Society will dedicate itself to opening new chapters in all die casting centers in the country. An aggressive membership program will be pursued to ensure that all die casters everywhere are informed of the aims and objectives of the Society. Chapters will be lent every assistance from the national office in improving their programs, particularly speaker schedules. With the equipment suppliers making almost daily progress in replacing the art in die casting with science and in automating the process, prompt communication of recent developments is vitally important.

The Society will continue to serve the entire industry by sponsoring bi-annual die casting shows where die casters from all over the world can gather to learn about recent improvements in suppliers' products and services, hear papers on the newest techniques and discuss common problems. Future technical Congresses will be fashioned around the most controversial subjects of the time. Exhibit coverage will be extended to include the very latest developments in *all* major

(Continued on Page 23)

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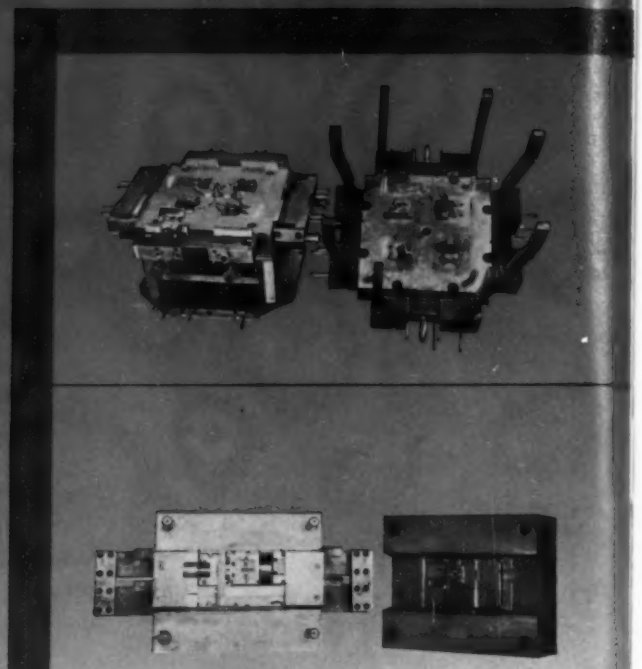

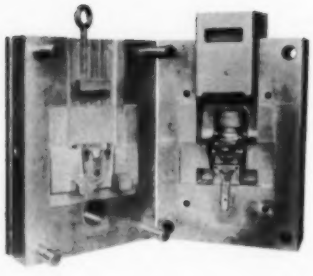

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Die Casting
ENGINEER

Influence of Gas Content, Pressure and Magnesium Content on the Mechanical Properties of Aluminum Die Castings

WERNER RUEGG

THE MANUFACTURING of aluminum die castings raises several metallurgical questions, which have been, up to now, not yet answered precisely. We should like to report on our experiments which should elucidate the influence of gas content, pressure and magnesium content on the mechanical properties of aluminum die castings.

It is a fact that the *gas content* of the liquid aluminum alloy influences the mechanical properties of sand- and permanent mold die castings. High metal temperatures cause gas absorption, i.e. absorption of hydrogen. This gas absorption is responsible for trouble on machined, polished and pressure tight castings. The elongation is especially unfavorably influenced by unsound metal[1].

Many practical difficulties encountered in the production of aluminum-base alloy sand castings and permanent mold castings are due to insufficiently controlled gas content[1-6]. It seems that a certain gas content is necessary to avoid local shrinkage defects in permanent mold die castings[7-8].

Little is known about the influence of gas content on the properties of aluminum alloy die castings. As Archbutt[9] has already shown it is quite possible to get die-chilled castings without gas porosity whereas aluminum alloy sand castings from the same melt contain gas holes. Frommer[10] stated the following about gas content of aluminum alloy melts provided for die castings: According to these findings it is best not to relate eventual macroscopic unsoundness in die castings to gas absorption in the liquid alloy, but to other causes. Doehler[11] also indicates the possibility of gas holes due to release of dissolved gases during solidification. Sachs[12] mentions liberated gases during solidification as one of three causes of porosity in die castings. He says that gas porosity is less prevalent in die castings than in sand castings. In a recent treatise on quality control of pressure die castings Sharp expresses his view on gas content of aluminum alloy and its influence on die castings[13].

He thinks that degassing of aluminum alloys is useless in die castings. The long period during which the liquid alloy is held in the holding furnace at a relatively low temperature favors the escape of hydrogen. It is not possible to prevent a contact between the metal and lubricants while die-casting.

Pressure is certainly essential in die casting. We remember the well known research work of Babington and Kleppinger[14]. The authors state that the castings from a special test die (ASTM Committee B-6 Test Casting) have the highest quality when cast with a high metal pressure of about 1400 kg/cm2. It is well understood that numerical pressure datas are very specific, i.e. they are related to the form of the casting and to the gate design. The metal pressure also influences the velocity of the metal when entering the die and the life of the die is indirectly affected (washout) by variations in pressure[15]. An interesting study on the effect of pressure on microporosity of aluminum sand castings incites thoughts in connection with die castings[16].

This study should also show whether an interaction between different factors is significant or not.

That was the reason why we introduced the *mag-*

(Continued on Page 14)

Specializing in electrochemistry and physical chemistry, Dr. Werner Ruegg received his Ph.D. degree from the Swiss Federal Institute of Technology in Zurich. He then joined Injecta Limited Die Casting and Manufacturing Works at Teufenthal, Switzerland. At present he is head of the Chemical and Metallurgical Laboratories and Research Department of Injecta Limited.

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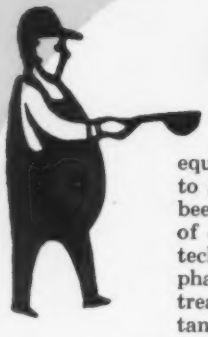

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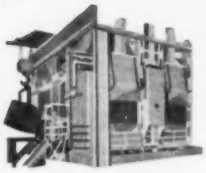

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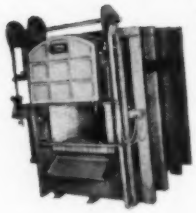

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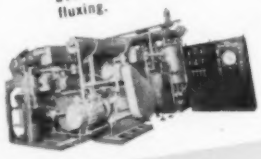

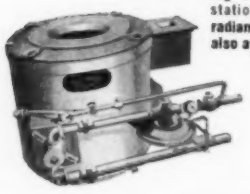

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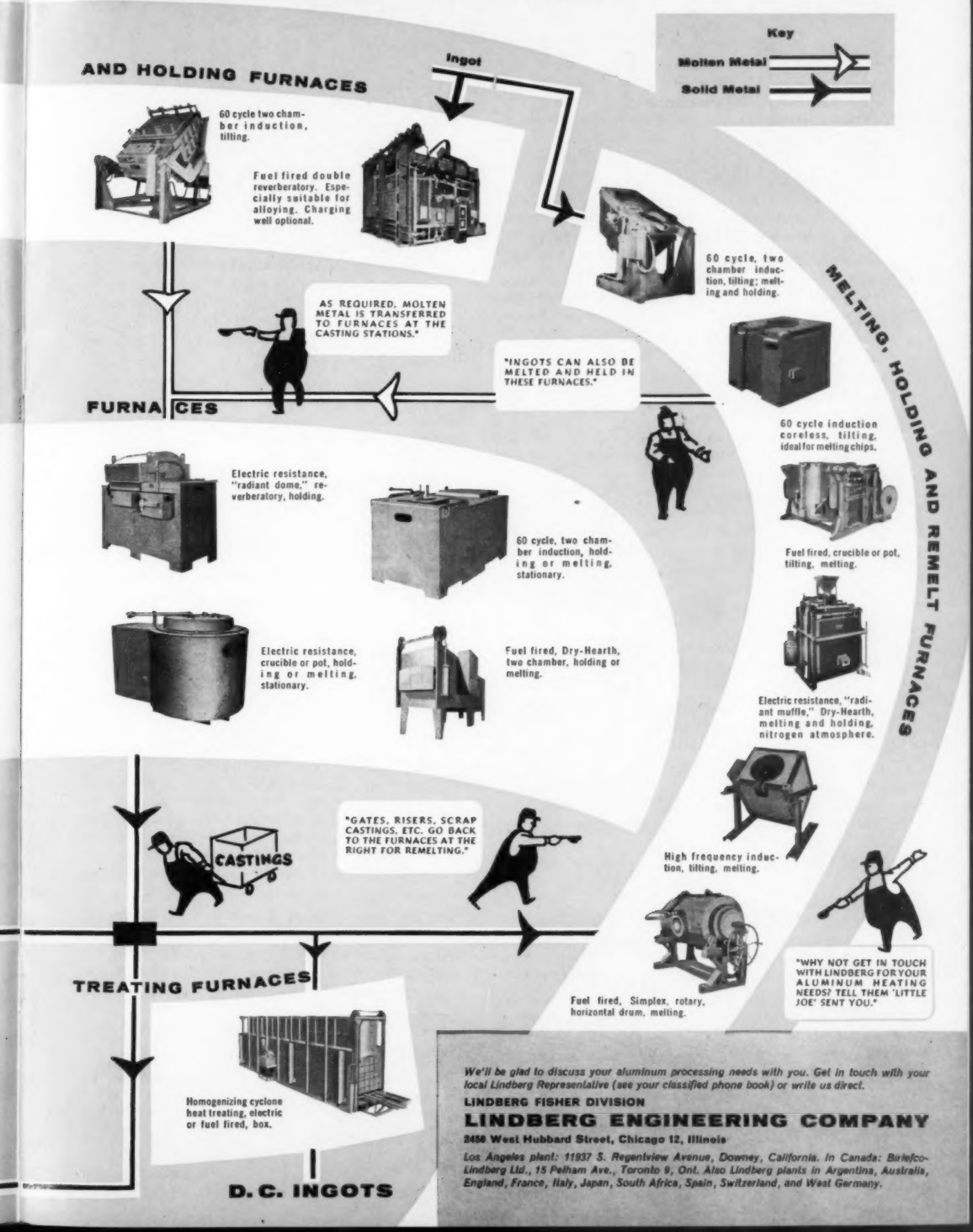
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Electric resistance, crucible or pot, holding or melting, stationary.
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Electric resistance, "radiant muffle," Dry-Hearth, melting and holding, nitrogen atmosphere.
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(*Continued from Page* 11)

nesium content as a factor, too. Magnesium acts as an element that produces a cold-hardening effect in die castings from Al-8Si alloy. The rapid cooling which is connected with the die-casting process acts like a chill after solution heat-treatment. This chill retains the Mg_2 Si- compound in solid solution.

By the cold-hardening effect elongation is lowered, the alloy becomes harder and more brittle, but the strength reaches higher proportions. Natural aging can be a useful tool to achieve better tensile properties of aluminum die-casting alloys of the type Al - Si with an additional amount of magnesium (0.3-0.5%).

EXPERIMENTS WITH DIE CAST TEST BARS

The experiments were made on a *die casting machine* of the vertical type (KMV 100; constructed by Injecta Limited, Teufenthal/Switzerland). After filling the vertical cold chamber with liquid metal, the operator commands a side movement of the filled chamber and a subsequent pressing action of the piston. This method of filling the die cavity should lead to less contamination of the oxides because there is less turbulence in this process in a horizontal pressure chamber.

The test bars coincide with ASTM-Standard: E 8-46. The die contains two test-bar cavities.

The *alloys* of high purity were melted in graphite crucibles and kept at casting temperature in an electrically heated holding furnace with gray-iron crucible. The inside of the crucible was protected by a white coating (mixture of kaoline and sodium silicate) against iron pick-up.

Metal treatment with fluxing salts was carried out in the melting crucible only. *As degassing* agent we used Degasser 400 FOSECO. The method of introducing gas, i.e. hydrogen, into the alloy by plunging fresh potatoes proved very useful[3]. By this procedure half a potato is fixed on an iron rod, which is protected by the before mentioned coating. This piece can be plunged into the liquid aluminum alloy without danger of explosion. The alloy appears to boil. The degree of gas content of the alloy was determined semi-quantitatively by a reduced pressure tester POROTEC* according to the method known as Straube-Pfeiffer test (reduced pressure during test: about 75-100 mm Hg).

Metal pressure was chosen at two levels. With the KMV 100 vertical die casting machine the piston (in this case, 50 mm diameter) can be operated at two different hydraulic pressures (120 and 400 kg/cm2). In combination with an additional pressure resulting from the kinetic energy we get pressures on the metal at the end of the shot-stroke of about 300 and 1000 kg/cm2.

The *design of experiments* was chosen from a statistical point of view. We considered three factors (gas content, pressure, magnesium content) each at two levels (low/high). The designations of the different possible combinations are indicated in Table I. The values for the two levels are:

Gas content:	0.1 cm3 /100gms**
	and
approx.	0.4 cm3 /100gms**
Pressure:	$3 \cdot 10^2$kg/cm2 and $10 \cdot 10^2$kg/cm2;
Magnesium content:	0 and 0.4%.

The holding furnace was charged with molten alloy (primary ingot material; nominal analysis—8.5% Si; 0.5% Mn; 0.2% Fe; 0.03% Cu***). The die was preheated to a temperature of about 100°C (=212°F). The molten metal (120 kg) was degassed by introducing degassing tablets. The process of degassing was controlled by the reduced pressure test. The sawn-through test castings of the whole experimental series are shown in *Figure 1*. The metal temperature could be kept at 650±10°C (1202±18°F) for all the combinations. The first shots of each combination were discarded. After getting cast test bars with homogeneous surface the following 25 shots were kept. Ten random samples of each series of 25 shots were selected for the mechanical tests. In every case the test bars marked L only were subjected to the mechanical tests.

The sequence of the different practical experiments is noted in *Figure 1*. While gassing the molten alloy by dipping potatoes, the alloy was constantly kept in a strong stirring movement by the evolved gases. During the gassing period no interruption of this "boiling" was allowed, to guarantee a sure saturation of the liquid alloy with hydrogen, resulting from the reaction:

$$2\,Al + 3\,H_2O \longrightarrow Al_2O_3 + 6\,H$$

The die-cast bars were mechanically tested on Amsler *testing* machines (10 t - Universal Testing Machine, 15 mkg Charpy type Impact Testing Machine). The stress-strain diagram was taken with a magnification of 20 x by means of a special mechanical device (so-called "Keildehnungsmesser"). The load for which the offset is 0.2% of the original gage length was determined from the diagram.

The numerical values for yield strength and tensile strength were not necessary for the envisaged statistical calculations.

The elongation at the moment of rupture which was determined from the diagram, must be reduced by subtracting strain at the elastic limit to get the real elongation at rupture (original gage length: 50 mm). After rupture the two ends of the test bar were subjected to the impact test on the Charpy Impact Testing machine. The distance of the two

*Produced by Foseco Ltd., Birmingham, England, and Cleveland, Ohio.

**The numerical values were not determined but estimated in comparison with gas contents at standard conditions, for which figures have been publishel in a recent study.[17]

***Corresponds approximately to the alloy A 360 but without magnesium.

(*Continued on Page* 16)

REED-PRENTICE

DIE CASTING NEWSLETTER

When rejects go up... check your gating and design first.

Gating of die casting dies is perhaps one of the most misunderstood aspects of the industry. While some experienced engineers can come up with a very good gating system after studying a casting, too often gate patterns just seem to "happen that way."

The reason: gating's function is misunderstood and thus misapplied.

Because die casting is a high-speed, high-production process, it is generally deemed desirable to keep the connection between the runner and the casting as small as possible. This makes degating an easier operation, one requiring unskilled labor.

Fact... and fiction

While ease of degating is a definite consideration, the most important aspect of gating a die casting die is to provide a metered entry of the metal, preventing its entering the die faster than air can be vented. For vents must be limited in size to an area no greater than will freeze off without splitting.

Gates are often used to try to build up pressure on the metal, but this is a fallacy. Pressure build-up occurs *in the runner*. No matter what the conformation of the gate, pressure in the casting does not build up *until* terminal filling has occurred.

Pity the machine

As far as the effect on machine performance is concerned, gating design can—and often is—carried to a ridiculous extreme. Gates are choked off with no consideration of the velocity of the metal, volume of metal, time of fill, or any factor except that the operator must be able to break the gate off by hand... quickly and easily. The machine is expected to have high speed, substantial pressure, and *lots* of it.

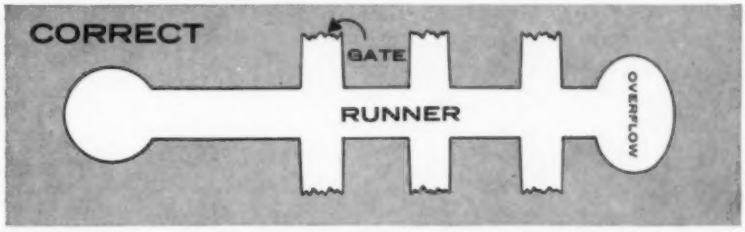
This is fine, but often it doesn't work. Too many castings have defects, rejects are up, and where do you place the blame? All too often, it's the machine's fault, or is it? Take another look at that gating design, and at the runners.

What runner pattern?

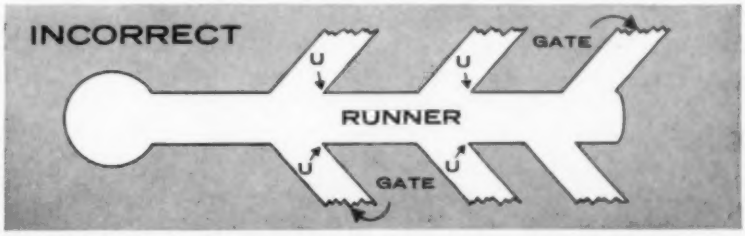
A runner is more than a means of conveying the metal to the gate. Consider it a high-pressure, smooth-walled conduit, with either a constant or reduced area that prevents expansion of the metal. Its size and conformation *are* important.

The simplified sketches here show a sound runner design and one other system which, though commonly used, tends to produce surface defects on castings.

If you are having casting trouble, why not check with your nearest REED-PRENTICE Sales Engineer. He'll be glad to consult with you.



With a straight runner, metal rushes to fill the overflow first, then the entire runner. It expands out from the center in a continuous flow, with equal force to both sides.



When a runner branches out at an angle, its upper edges (U) tend to catch a partial flow of metal. Small amounts are injected into the cavity before filling volume is available, causing a cold shot and rough, porous castings.

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INFLUENCE OF GAS CONTENT

(*Continued from Page 14*)

supports was chosen at 40 mm, and the total energy of the hammer was 9.5 mkg in each experiment.

The structure of the test bars shows no remarkable differences between the gate side and the opposite side. The spectrographic analysis of some test bars showed that no alteration in composition had taken place while the alloy was being held in the bale-out furnace. The magnesium-containing alloy—alloying was made with pure magnesium—did not lose any amount of this element for the whole time of the subsequent experiments.

The results of mechanical testing are summarized in Table II. The average of the different combinations shows that the quality of the die castings can be compared with the quality level of test bars used for the establishment of the product standards ADCI —M2 and M3—55T.

The procedure of statistical analysis[19] is shown by the example of tensile strength. The eighty measurements are given in Table III. To determine whether there is a significant influence of gas content, pressure and magnesium content on the tensile strength or a significant interaction of the three factors, the analysis of variance (Table IV) proved useful.

The sums and differences are calculated by the method of Yates. The sum of squares of the different actions and interactions can be compared with the mean square between readings within combinations: F = Mean Square (action or interaction) : 1245.084
Table IV contains the respective values F0.05 = 3.98
F0.01 = 6.99

If F is bigger than F0.01 the corresponding action or interaction is significant, when bigger than F0.05 but smaller than F0.01 the action or interaction is significant with a 5% risk that samples are considered to be significantly different, while they are really not significantly different.

As a result of this analysis the influence of pressure and magnesium content on the tensile strength is significant at the 0.01 level. A significant influence of gas content or any interaction between factors cannot be found.

The analysis of variance for the further tested properties is summarized in Table V. Pressure and magnesium content are significant at the 0.01 level in all five tests of mechanical properties. To a much lesser extent we can observe a significant importance of the interactions between magnesium content and the two other factors on the mechanical properties. The influence of gas content on the mechanical properties is shown as being practically non-significant.

STUDIES ON DIE CASTING

The preceding experiments showed that gas content has a very small influence on the mechanical properties of die-cast test bars. The relatively simple form of a test bar with more or less uniform area of cross-section without abrupt changes in wall thickness favours a rapid chill.

Experiments with normal die castings should show whether variations in wall thickness could alter the effect of gassed metal.

Some preliminary tests with a smaller piece (overall length 9 cm) shown in *Figure 2* resulted in no evident difference in porosity between die castings from degassed or gassed alloy (type Al-5Si-Mg). This casting was also made on a vertical die casting machine as described before.

To throw some light on the influence of dissolved gas on the soundness of the casting a series of housings were cast on a die-casting machine with horizontal cold-chamber.

Three different qualitative tests were made to evaluate the gas content of the molten alloy *(Figure 3)*. In the pouring test, the alloy was poured into a ceramic mold with a small heat conductivity****. Gas bubbles, which build-up during cooling in the mold, come up to the surface and build there distinct raised pin marks. In a turned cross-section of a fractured test piece the pores can be seen without magnifying. Naturally a test under reduced pressure exaggerates the difficulties caused by gas. The radiographs illustrate the most interesting fact that the gassed alloy after die casting is certainly not more porous than a housing cast from degassed or normal metal. The gassed piece even seems to show less porosity than the others. Photomacrograph of the turned sections persuades us to believe that shrinkage is one of the important factors causing the mentioned porosity. Also in this case microstructure of pieces from degassed and gassed metal shows no significant difference.

The experiments with die casting were completed with parts cast by the reduced back-pressure method. Burner covers (alloy: Al-8Si-2Cu) sometimes show blisters near the surface of the die castings. Die casting was done at temperatures near the liquidus line of the alloy. These pieces cast from normal, gassed and degassed alloy were heated to 380°C (=716°F), and it was not possible to notice any remarkable difference in the tendency to blistering during heat-treatment (3 hours at 380°C).

DISCUSSION AND CONCLUSIONS

The die-casting process is very complex, and it is difficult to give the results of a special experiment a general meaning. The most important object of the experimental work published in this paper was to show whether gas content of the liquid alloy is significant to the mechanical properties of the die casting. The choice of a vertical die-casting machine avoided the unreproducible introduction of air into

****This method is very simple to carry out and can act as an inexpensive field method for controlling the gas content in sand- and permanent mold casting. We were informed of this method by Mr. Businger, Refonda & Co., Niederglatt, Switzerland.

(*Continued on Page 18*)

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INFLUENCE OF GAS CONTENT
(*Continued from Page* 16)

the liquid alloy during the motion of the piston in the filled cold-chamber.

The statistical evaluation of the results brings us to the conclusion that *gas pick-up,* i.e. hydrogen content of the aluminum alloy, *is not of a significant influence on the mechanical properties.* This confirms the statements of experienced die casters. Casting design, including gate and overflow well design and other constructional details of die design, influence the soundness of castings as much, when not even more as hydrogen dissolved in the alloy. This conclusion is only entirely valid for the very experiments carried out with test bars.

Preliminary research done with die castings that vary in wall thickness shows that porosity in thicker sections, which is due to shrinkage effects, is not negatively affected by using gassed metal. A rough calculation makes it clear that the fineness of porosity can influence the mechanical properties of the alloys. If we assume a gas content of 1% of the volume of the die casting (we determined porosities of 1.3 to 3.3%) distributed regularly all over the cross-section in pores of 0.1 mm diameter, then the load-bearing area of metal in cross-sections will be less than 97% of the area of compact metal. With pores of 0.5 mm diameter this figure is $<96\%$.

We must take into account that the volume of the gas-micropores is highly affected by pressure. A hydrogen concentration of 0.4 cm3/100gms aluminum alloy at standard conditions corresponds approximately to 4% void volume at 1 atm[16]. This percentage is reduced when pressure becomes higher. At 300 atm it will be—according to Boyle's law—only 0.04%. As mentioned before, structure of gassed die castings can be distinguished from a normal structure, i.e. we cannot perceive a disturbing microporosity.

It is interesting to notice a distinct *increase of the yield strength* by the *magnesium addition.* The tensile strength rises to an average of 30.4 kg/mm2 after the addition of 0.4% Mg. Without magnesium the average tensile strength is found to be 27.9 kg/mm2. This results in a 9% improvement of the values for the magnesium-free alloy by the magnesium content.

For the yield strength the figure is

$$\frac{15.4 \text{ kg/mm2}}{11.8 \text{ kg/mm2}} = 1.30, \text{ i.e. } 30\%$$

This paper tries to show that the mechanical behavior of aluminum alloy die castings depends more on process variables (pressure, die and metal temperature, etc.) of die casting and die design, composition of the alloy, and not on metallurgical treatment of the alloy to reduce gas content.

Table I—Design of Experiments

Combination	Level of Factors		
	Gas Content	Pressures	Magnesium Content
(l)	low	low	low
p	low	high	low
g	high	low	low
pg	high	high	low
m	low	low	high
pm	low	high	high
gm	high	low	high
pgm	high	high	high

Table II—Results of Testing Mechanical Properties of Die Cast Test Bars (Ten measurements for each combination)

Combination	Yield Strength* (0.2% offset) kg		Tensile Strength* kg		Elongation** (gage length 5omm) % · 100		Impact Strength*** (Gate Side) cm · kg		Impact Strength*** (Overflow) cm · kg	
	Average $\bar{x}$	Standard Deviation δ	$\bar{x}$	δ	$\bar{x}$	δ	$\bar{x}$	δ	$\bar{x}$	δ
(l)	367.3	4.8	861.1	21.3	375.4	72.9	219.0	30.7	123.0	17.7
p	387.5	8.8	893.3	8.8	484.4	41.7	265.5	30.1	203.6	34.2
g	335.3	13.9	845.4	13.6	417.2	61.7	234.3	22.9	159.2	18.8
pg	378.9	17.8	879.5	12.1	462.7	51.0	280.5	38.3	200.0	25.3
m	453.0	14.9	933.0	49.3	326.5	98.6	140.0	25.0	90.8	12.4
pm	508.5	16.6	973.0	71.8	372.1	111.7	148.9	17.0	129.2	18.0
gm	456.2	12.7	901.7	36.2	256.1	44.8	120.8	26.0	102.7	21.1
pgm	499.1	6.9	988.0	14.5	396.6	48.5	143.7	9.2	110.2	11.2

*The values in the table are loads in kg; to calculate the strength, the values must be divided by F_0 (original area of cross-section of the test bar) = 31.17 mm2.
**To have the true elongation the elastic part of the elongation would have to be subtracted from the elongation indicated by the diagram.
***The table contains the values of lost energy of the pendulum striker. The area of cross-section of the test bars was about 70 mm2.

Table III—Tensile Strength of Tested Bars

Combination	Single readings for P_{max} [kg]*										Average $\bar{x}$	Standard Deviation δ
(l)	872	855	866	843	813	854	871	884	884	869	861.1	21.3
p	901	905	903	894	890	886	894	875	894	891	893.3	8.8
g	852	843	814	856	858	845	854	855	832	845	845.4	13.6
pg	903	873	856	883	884	871	883	879	886	877	879.5	12.1
m	927	923	930	917	814	987	944	934	991	963	933.0	49.3
pm	1004	981	1010	966	973	995	1013	1007	774	1007	973.0	71.8
gm	880	894	938	945	841	904	956	889	866	904	901.7	36.2
pgm	964	1004	997	988	1000	992	962	986	987	1000	988.0	14.5

$$*\delta_B = \frac{P_{max}}{F_o} \quad \begin{cases} \delta_B & \text{tensile strength} \\ P_{max} & \text{maximum load} \\ F_o & \text{original area of cross-section} \end{cases}$$

(*Continued on Page* 21)

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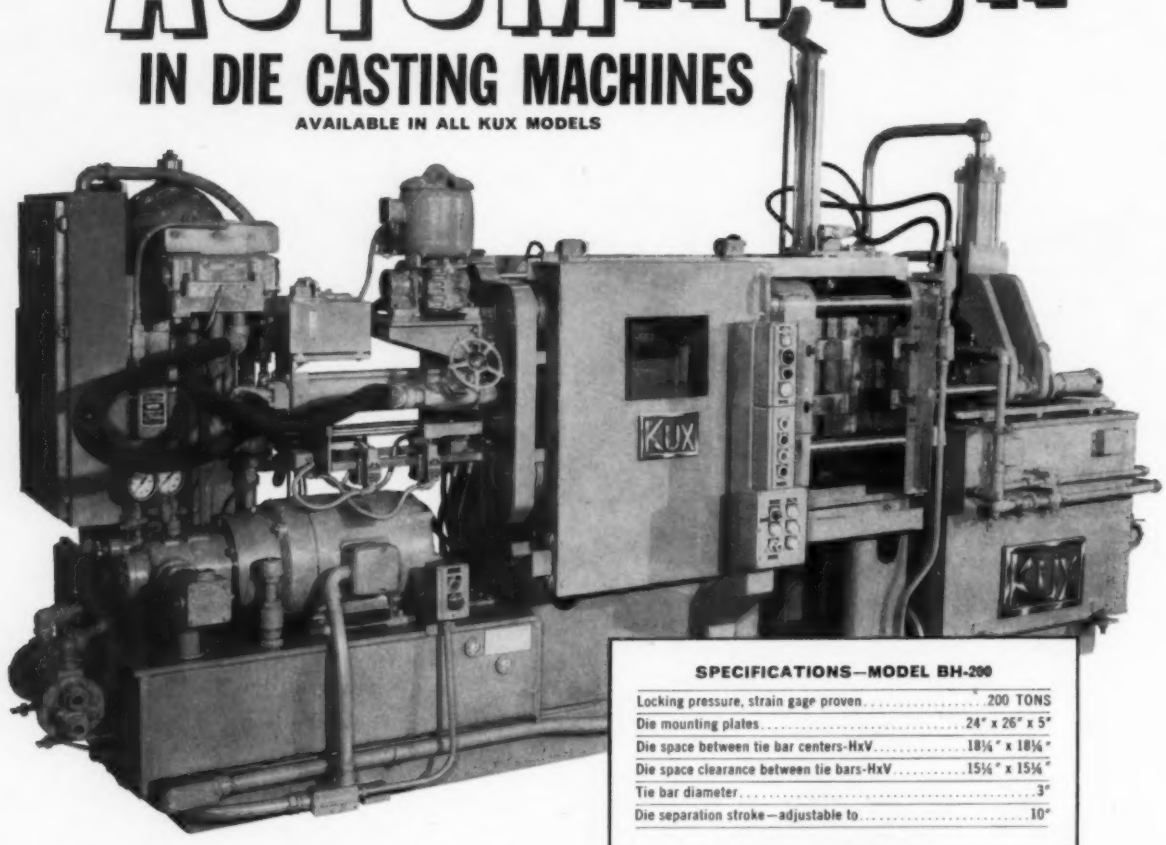

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Die mounting plates	24" x 26" x 5"
Die space between tie bar centers-HxV	18¼" x 18¼"
Die space clearance between tie bars-HxV	15½" x 15½"
Tie bar diameter	3"
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(Continued from Page 18)

Table IV—Statistical Analysis of the Results of Tensile Strength Testing.

Sums and Differences (Method of F. Yates)					
(1)	8611	17544	34793	72750	Sum
p	8933	17249	37957	1926	P
g	8454	19060	663	— 458	G
pg	8795	18897	1263	482	PG
m	9330	322	— 295	3164	M
pm	9730	341	— 163	600	PM
gm	9017	400	19	132	GM
pgm	9880	863	463	444	PGM

Source of Variability	Degree of Freedom	Sum of Squares	Mean Square
P	1	$\frac{1926^2}{80}$ = 46368.45**	Mean Square = Sum of Squares
G	1	$\frac{-458^2}{80}$ = 2622.05	
PG	1	$\frac{482^2}{80}$ = 2904.05	
M	1	$\frac{3164^2}{80}$ = 125136.2 **	
PM	1	$\frac{600^2}{80}$ = 4500.0	
GM	1	$\frac{132^2}{80}$ = 217.8	
PGM	1	$\frac{444^2}{80}$ = 2464.2	
Between the combinations	7	184212.75	26316.107
Between readings within combinations	72	89646.05	1245.084
Total	79	273858.80	

$$F = \frac{\text{Mean Square (action or interaction)}}{\text{Mean Square (between readings within combinations)}}$$

for $n_1 = 1$; $n_2 = 72$ F (0.05 level) = 3.98 } see e.g.
F (0.01 level) = 6.99 } A. Linder[10]

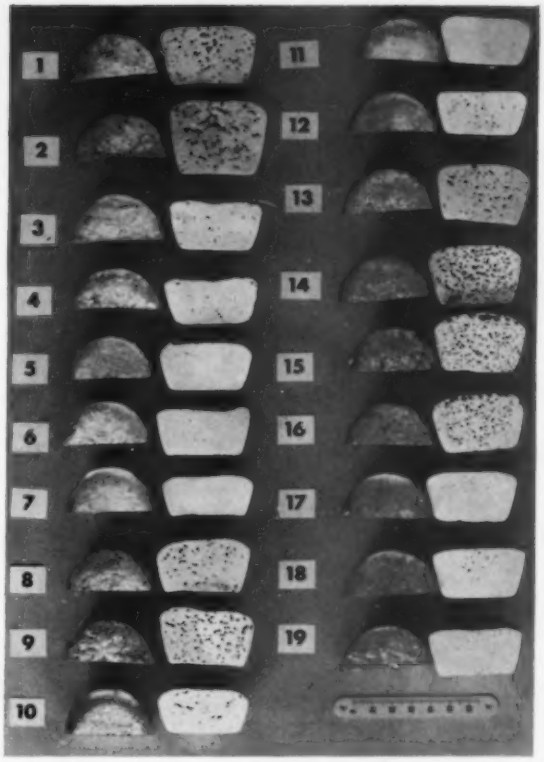

Figure 1—Test Castings under Reduced Pressure to control the level of gas content during the die casting experiments.

No.	Die casting experiments	
1 to 4		Degassing
5, 6	(1)	Degassing
7	p	Degassing
8	pg	Gassing
9, 10	g	Gassing
11	m	Degassing
12	mp	Degassing
13	mpg	Gassing
14	mg	Gassing
15 to 19	further experiments, not included in this study.	

Table V—Analysis of Variance

Source of Variability	DF	Yield Strength SQ	MS	Tensile Strength SQ	MS	Elongation SQ	MS	Impact Strength (Gate Side) SQ	MS	Impact Strength (Overflow) SQ	MS
P	1	32886.05**		46368.45**		145010.45**		19375.31**		34986.61**	
G	1	2737.8**		2622.05		832.05		43.51		812.81	
PG	1	145.8		2904.05		1232.45		234.61		6248.11**	
M	1	250656.05**		125136.2 **		188568.20**		248533.51**		79948.01**	
PM	1	1496.45**		4500.0		1248.20		4636.01*		7125.31**	
GM	1	1479.2 **		217.8		5445.0		3740.11*		1970.11*	
PGM	1	1620.0 **		2464.2		31363.2 *		255.61		99.01	
betw. readings within combinations	72	11898.60	165.26	89646.05	1245.08	360157.2	5002.18	49661.70	689.75	31738.90	440.81
Total	79	302919.95		273858.8		733856.75		326480.39		162928.89	
$F_{0.05}$.MS {betw. readings within combinations}		657.73		4955.43		19968.69		2745.19		1754.46	
$F_{0.01}$.MS {betw. readings within combinations}		1155.15		8703.11		34965.26		4821.32		3081.32	

for $n_1 = 1$ $n_2 = 72$ $F_{0.05} = 3.98$
$F_{0.01} = 6.99$

(Continued on Page 23)

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(*Continued from Page* 21)

Figure 2—Aluminum Die Casting and Alloy Samples solidified under reduced pressure.
1. low gas content
2. high gas content

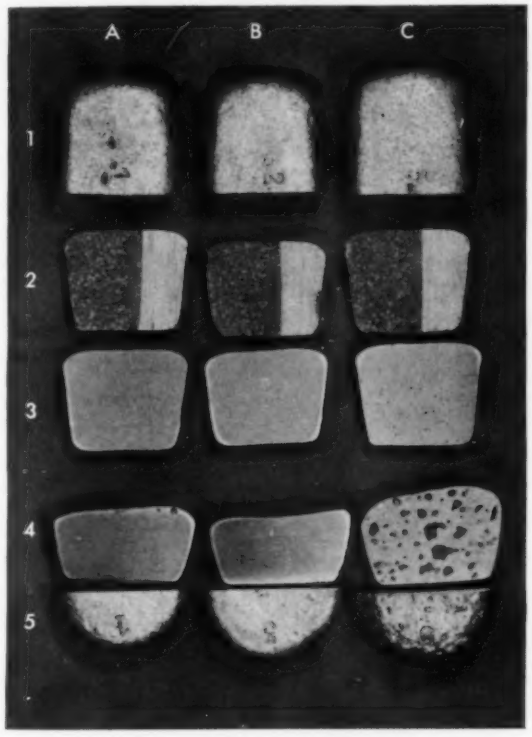

Figure 3—Qualitative Test of Gas Content
A Normal alloy (Al - 8 Si - 2 Cu)
B Degassed alloy
C Artificially gassed alloy
1. Pouring test
2. Fractured surface of test piece
3. Turned surface to make visible gas porosity
4. Porotec sample
5. Surface of porotec sample

REFERENCES

[1-19] References may be obtained from the Society of Die Casting Engineers.

ACKNOWLEDGEMENTS

The author desires to express his thanks to Mr. E. Trachsel, General Manager of Injecta Limited, Die Casting and Manufacturing Works, Teufenthal, Switzerland, for the great interest he has taken in the work and for permission to publish the results contained in the paper.

(*Continued from Page* 8)

product lines used by the industry. Attendance at these affairs will be prompted vigorously, not only among die casters, but also among the product designers who finally make the decision for or against incorporation of die cast parts in consumer products. This latter group has tremendous influence in determining where and how die castings are used—we propose to do our best to educate the product designer to the advantages of die cast design.

The *Die Casting Engineer* is now published every other month. As soon as new member circulation and advertiser patronage can be built up high enough, the magazine will be issued monthly. As revenues permit, technical article content will be increased, as will other departments bringing up-to-date news of the industry to the reader.

Other activities such as determination of equipment standards will be pursued with enthusiasm. We plan introduction of educational programs and research projects to explore some of the fundamental aspects of the process just as soon as adequate funds are available. Another tour of Society members, larger than the first, will be organized to visit European die casting plants and attend the Fourth International Pressure Die Casting Conference to be held in 1963 at Munich, West Germany.

The Society is poised and ready to "soar" with the '60s. Within the current decade individual membership should triple to 3,000, chapters should at least double in number to 20 or more. Given the support of all segments of the industry, the Society will adequately fulfill its responsibilities towards die casters nationally by helping them acquire the knowledge needed to meet the challenge of the '60s.

BOUND BOOKS OF 1960 CONGRESS PAPERS NOW AVAILABLE

Bound volumes of the 30 technical papers presented at the First National Die Casting Congress held in Detroit November 8 to 11, 1960 have now been mailed to all those who registered for the Congress as well as to authors and moderators.

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Chapter News

CLEVELAND CLINIC A SUCCESS

THE die casting clinic sponsored by SDCE Cleveland Chapter at Hotel Carter, Cleveland, Ohio on April 19, was declared by Chapter officers an important success from the standpoint of both exhibitor and visitor. The affair, designed to assist users of die castings and designers of components learn how the supplier can be of help in the technical area, attracted a stream of over 200 purchasing agents, manufacturing executives, engineers and guests from locations as far as 300 miles from Cleveland.

The eleven suppliers of die castings who carried displays of raw and semi-finished castings as well as completely assembled products incorporating die castings as major components were: Conneaut Die Casting Co., Conneaut, Ohio; Die Cast Products Corp., Cleveland, Ohio; Halex Die Casting Co., Cleveland; Ray Lewis & Sons, Inc., Marysville, Ohio; Laco Die Casting Co., Cleveland; Nelmor Mfg. Co., Euclid, Ohio; Tool Die Engineering Co., Cleveland; Westinghouse Electric Co., Cleveland; White Industries Inc., Cleveland; Wise Die Casting Co., Rochester, New York; Yoder Industries Corp., Dayton, Ohio.

This first SDCE-sponsored clinic has demonstrated the worth of the idea in stimulating new thinking at the point of application, and should encourage repetition of the activity in other Chapter areas.

WESTERN MICHIGAN

3 The April meeting held at the Southern Restaurant in Grand Rapids was a real success with over 100 die casters and guests present from Benton Harbor, St. Joseph, Kalamazoo, Big Rapids, Holland, Lake Odessa, Grand Rapids, and Detroit. Bob Carroll, Ternstedt Division of General Motors in Flint, showed their color film on the training of die casting foremen. It is an excellent film and was extremely well received.

—Carl Neuendorf, Chapter Correspondent

TOLEDO

4 The Toledo chapter of SDCE has been favored recently with extremely fine programs. At the March meeting Jim Kelly of Die Casters' Services, Inc., was again the guest speaker. His December talk was so well received that he was asked to return to complete his enlightening discussion.

At the April meeting Crucible Steel Company of America provided their interesting and informative movie "Manufacturing Steel from Ore to Finished Product."

In May the chapter will see the movie "Gating," prepared by the G. M. Technical Center and offered by the Brown-Lipe-Chapin Division of General Motors.

Our chapter was highly commended for its display during "Die Casting Engineers Week" in Toledo to which area die casters contributed.

—Robert Allen, Chapter Correspondent

CHICAGO

5 The chapter is planning its annual Golf Outing scheduled to be held on June 29 at the Glendale Country Club. Other chapter members are invited to plan their schedules so they may attend and have a part in the festivities, which will feature prizes and an out-door bar-b-que.

—Marton Vormann, President

CLEVELAND

6 The March meeting of the Cleveland chapter was held at Harry Mamolens Restaurant. A record turnout of over 75 members and guests saw the film offered by the Brown-Lipe-Chapin Division of General Motors on the utilization of quartz dies in the actual filling pattern during injection. In addition, films taken during the European tour of last May were shown. Credit for arranging the program goes to Mr. L. Pearch and Harry Cagin.

We would like to publicly thank all who attended and exhibited at the Cleveland die casting clinic on April 19 for it was through your efforts and attendance that the show was a great success.

J. B. Kelley

Mr. J. B. Kelley, prominent member of Cleveland Chapter and well known in die casting circles for his interest in lecturing on technical services, has recently formed his own company, Die Casters' Services, Inc. to manufacture goosenecks, plungers and other replacement items used by die casters. Headquarters are at 2012 West 25th Street, Cleveland.

The next meeting will be held on May 16, again at Mamolens Restaurant, at 6:00 p.m. The guest speaker will be Tom Lester, Lester Casting, Inc., Bedford, Ohio. His topic: "Gating and Venting of Dies."

—E. J. Hinkel, Secretary

NEW YORK

7 Mr. G. L. Wereley of the New Jersey Zinc Company was the guest speaker at the March meeting held at the Governor Clinton Hotel in New York. His interesting talk covered the development and introduction of the Zamak alloys. The properties of Zamak 7, methods of production of the alloy, recommended usage, alloying elements and effects of Zinc purity were discussed fully. An unusually active question and answer period followed.

—John G. Thomas, Chapter Correspondent

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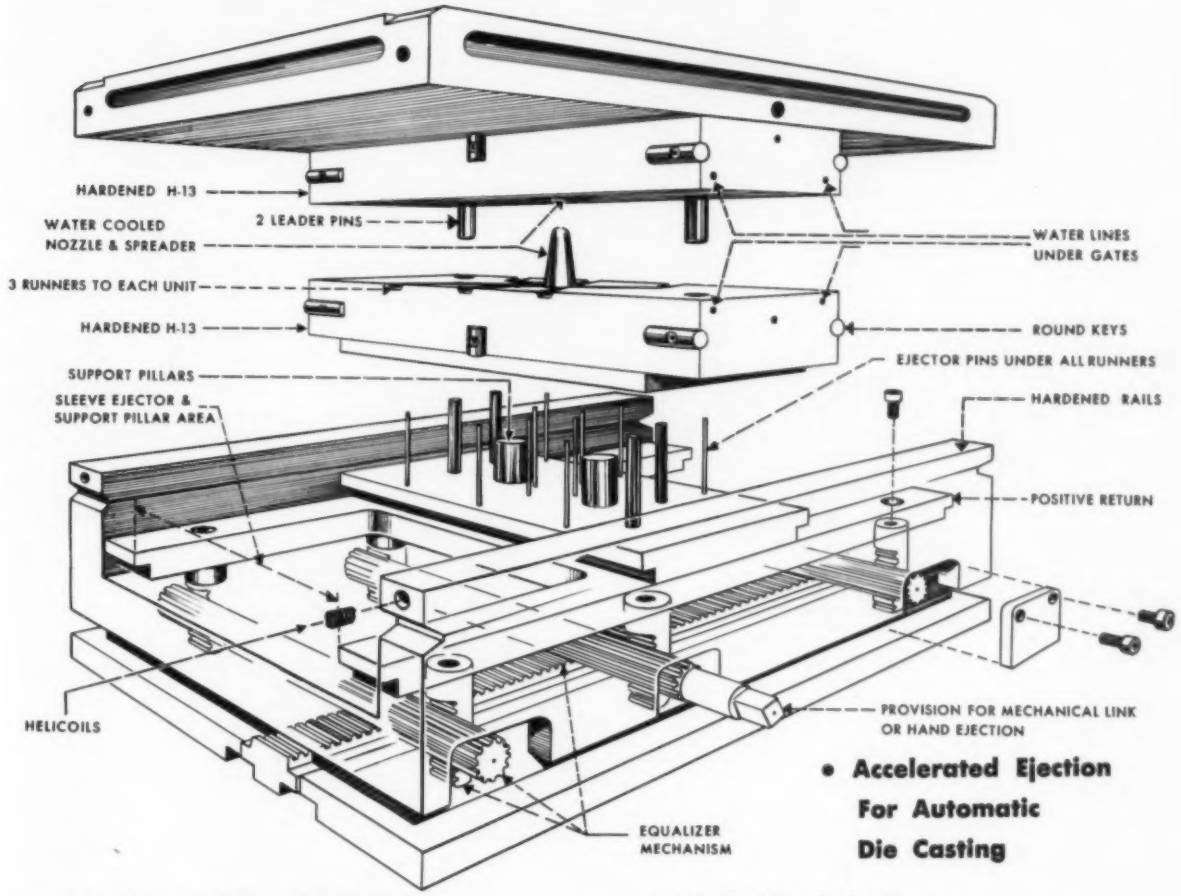

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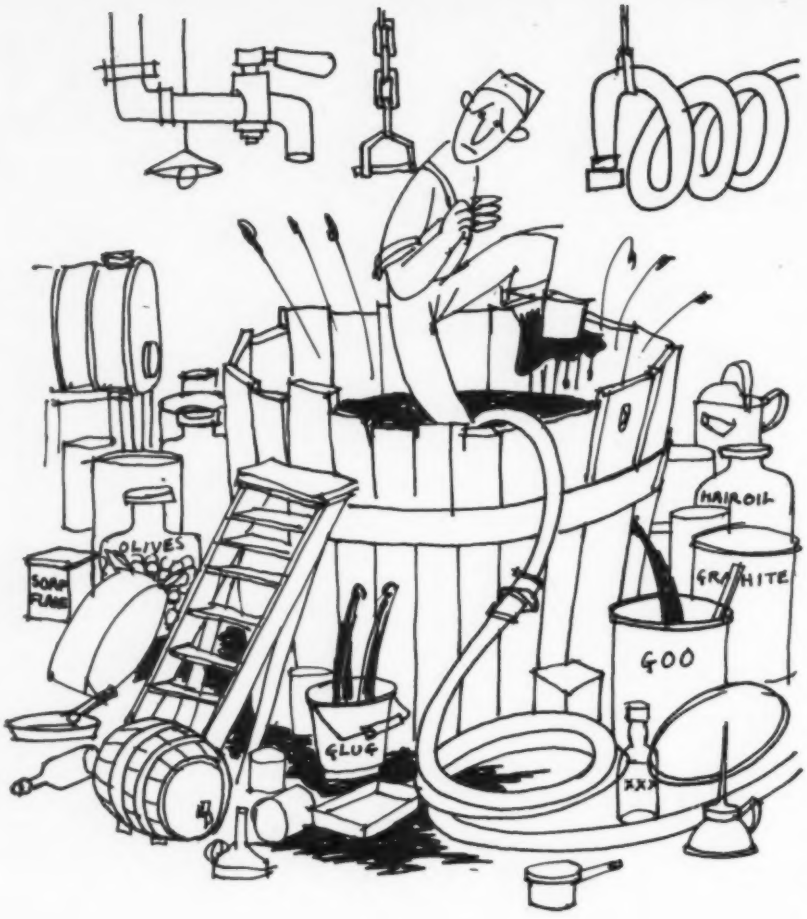

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ERNEST W. HORVICK

ALLOY CONTROL FOR ZINC DIE CASTINGS

ZINC alloys for die castings were developed largely in the 1920's and the early 1930's. Since that time, their use has expanded at a remarkably steady rate. In the earlier days of market development, substantial efforts were made, via extensive sales engineering service programs, to assist the die casters into an understanding of the needs for process control, with emphasis on the chemistry of the alloys—and with substantial success. However, the die-casting industry has grown so much, and the consumption of zinc within it has now reached such proportions, that the fundamentals of alloy control should be restated. Attrition through death and retirement of early die casters, plus market expansion—both since the 1930's—have caused great changes in personnel throughout the industry. There are many men in responsible positions throughout the die-casting industry today who have not learned of the need for chemical control of zinc die castings from a zinc industry point of view. Unfortunately, many of the relative newcomers are dependent on second hand information or casual and sometimes questionable contact with the literature, for their knowledge of what is involved and what safeguards are needed.

In the very early days of die casting with zinc, there was small knowledge of the importance of alloy chemistry. As a result, many zinc alloys were used and additions of all sorts were frequently made at the whim of the die caster, who threw into the pot whatever he felt would help. Die-cast parts failed to perform due to growth, distortion and cracking.

In the late '20s and early '30s, the importance of alloy control became understood, and today's high purity alloys were developed. The commercial availability of 99.99% pure zinc made the improvement both possible and practical. In spite of superior knowledge and the availability of proper materials, the early mistakes and misunderstandings needed a great deal of undoing. A study of zinc die casting failures for all reasons in the late 1930's still showed that 2/3 or more resulted from impure alloy.

Great improvements have been made, and today, failures due to poor alloy are rare. Nevertheless, the threat is ever present and misunderstandings persist.

Personal experiences in very recent times include vivid examples:

A development engineer in a major corporation was of the impression that it was inevitable for zinc die castings to become brittle in two or three years. It developed on exploration, that his personal contacts with the product had involved the preparation of sample die castings from materials assembled by "sweeping the floor" in a model shop. Another example involved the purchasing department of a major corporation engaged in die casting where there was no reluctance whatever to purchase alloy ingot of doubtful origin for the sake of a saving less than 1¢ per pound, and certainly without an awareness of the risk incurred. The application of zinc to die casting is so basically sound that it should not be dependent on the false economies which are suggested by the instances mentioned.

It is important to eliminate such questionable practices, and to use vigorous chemical control, if proper die castings are to be manufactured.

The American Bureau of Metal Statistics reports the following on the use of metals by the die-casting industry of the United States during recent years (Table 1).

TABLE 1

DIE CASTINGS	1956	1957	1958	1959
Aluminum (tons shipped)	188,115	186,793	146,300	182,412
Zinc base Alloy (*tons slab consumed)	360,507	376,039	316,830	370,330
Brass (**tons consumed)	....	....	4,650	6,750
Magnesium (**tons consumed)	....	....	1,800	2,400

*Includes small amounts used for stamping dies also slush and sand castings, e.g., 5,278 tons in 1959 total for such categories.
**American Die Casting Institute.

Table 2 gives basic comparisons of die casting properties. *(Note:* The data on "Delrin" is included for general information on a new plastic being offered in competition with metal die castings.)

Cost and production factors which favor zinc alloy over other metals include:

Low metal cost.

Low melting point and casting temperature range —low fuel cost and low maintenance.

Slow rate of attack by molten metal on dies and machines.

High speed production—hot chamber process.

(Continued on Page 28)

Mr. J. L. Kimberley, executive vice president of the American Zinc Institute, has been engaged in the metallurgical field in various capacities, including laboratory, production control, sales engineering, and sales management. Mr. Ernest W. Horvick, market development engineer of the American Zinc Institute, has also been associated in technical, supervisory, and marketing capacities.

ALLOY CONTROL *(Continued from Page 27)*

TABLE 2

PHYSICAL PROPERTIES AND CHARACTERISTICS	ZINC ASTM AC40A (XXIII) ZAMAK 3	ALUMINUM* ASTM SC84B (SAE) 308	DELRIN**
Specific Gravity	6.6	2.72	1.425
Melting Point	728°F	1100 approx.	347°F
Coeff. Linear Expansion /°F	1.52×10^{-5}	1.2×10^{-5}	4.5×10^{-5}
Tensile Strength—Room Temp.—As Cast	41,000 psi	43,000 psi	10,000 psi
After 10 yrs. aging	35,000 psi	....	....
Elongation—2"—Room Temp.—As Cast	10%	2%	15%
After 10 yrs. aging	16%	....	....
Izod Impact—Room Temp.	....	....	1.4 ft. lbs./in.
Charpy Impact—Room Temp.—As Cast	43 ft. lbs.	3.2 ft. lbs.	....
After 10 yrs. aging	41 ft. lbs.	....	....
Compression Strength	60,000 psi	....	5,200 psi (1% Def.)
Shear Strength	31,000 psi	28,000 psi	9,510 psi

*Properties and constants from authoritative sources
**From DuPont Handbook A4476 (107 pgs.)

TABLE 3

	ASTM B6 Slab Zinc Special High Grade FOR DIE CASTING ALLOYS	ASTM B240-57T Zinc-base Ingots for Die Castings AG40A	AC41A	ASTM B86-57T Zinc Alloy Die Castings AG40A	AC41A
Copper %	....	0.10 max.	0.75 to 1.25	0.25 max.	0.75 to 1.25
Aluminum %	....	3.9 to 4.3		3.5 to 4.3	
Magnesium %	....	0.03 to 0.06		0.03 to 0.08	
Iron — Max. %	0.005*	0.075		0.100	
Lead — Max. %	0.005*	0.005		0.007	
Cadmium — Max. %	0.004*	0.004		0.005	
Tin — Max. %	0.002	0.002		0.005	
Zinc %	Remainder	Remainder		Remainder	

*Sum of Pb, Fe, Cd 0.010% Max.
NOTE: Significant footnotes have been eliminated from this tabulation.

(Continued on Page 29)

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The facts showing the volume in which zinc die castings are used and the table of physical properties well illustrate the basic soundness of the material's position in our industry. In order to produce attractive, sound, and long-lived castings, many factors are important. Basic die design (including proper arrangements for gating and venting), casting temperature, die temperature, cycle speed, die lubrication, die steels—all must be properly conceived, arranged, and executed. Much work has been done in these important areas and great good has been accomplished. Further advances can be anticipated.

WHAT MUST BE CONTROLLED

Zinc die-casting alloys are highly sensitive to variations in chemical composition. It is the purpose of this paper to expand your awareness of this fact and to indicate, not only the facts of what happens when proper alloy control is disregarded, but also to suggest ways and means for preventing the problems which will inevitably develop if alloy chemistry is discounted. Unless the control of alloy composition is properly established and administered, all other controls and safeguards may well prove to be of secondary importance. Neither control of dies nor die temperature, die release agents, nor any other phase of processing, can compensate for the use of an improper alloy. Fortunately, the ranges of composition—both as to added elements and impurities—are sufficiently broad as to require only reasonable sound shop practices, and care. While the costs of alloy control are real and must be considered, they are not major. The important hurdle is passed when the need is fully understood, and sound practices have been introduced with suitable provisions for their consistent observance. Good housekeeping is a primary essential. It is my conviction that a sound and well executed plan for control plus good housekeeping will bring related bertefits of more than enough economic value to offset the minor additional costs of controlling the material to be melted and insuring the continuance of its quality through the molten stages and into the finished castings.

ASTM Specifications B6—Slab Zinc, B240—Alloy Ingot, and B86 — Die Castings, define the chemical requirements of zinc or zinc material from which die castings must basically be made, and of the final product. Table 3 lists their chemical limits.

(Continued on Page 30)

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2—Reed-Prentice #1½ 225 ton Zinc 1950
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2—Kux BH-18 Zinc 350 ton 1949
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ALLOY CONTROL

(Continued from Page 29)

The purposes for the alloying elements, particularly, aluminum and magnesium and the actual influences of the impurities listed, (referring to Specification B86 for Castings as shown in the last column) are reviewed in the following paragraphs.

ALUMINUM

(3.5 to 4.3%)

Aluminum is the essential ingredient added to zinc for die casting and serves to strengthen the alloy and to minimize the attack of the molten metal on the iron and steel in the casting system and machines. Aluminum adds substantially to the fluidity of the molten metal and improves its castability.

Aluminum contents below the minimum Specification level would have an adverse influence on the benefits described and are certainly to be avoided. In the case of really low aluminum, (on the order of 2%) not only would there be danger of attack by the molten zinc on the dies and machinery, but there would also be real difficulty in proper filling of die cavities involving thin walls or complicated shapes.

High aluminum (over 4.3%, the Specification maximum) has a seriously adverse influence on impact strength, and castings produced from such material are brittle. The zinc-aluminum-alloy system results in structures which are 100 per cent eutectic at about 5 per cent aluminum content. This eutectic alloy is exceedingly brittle and must be avoided.

MAGNESIUM

(0.03 to 0.08%)

Magnesium must be added, but must be controlled carefully, ideally, it should be held in the lower half of its permissible range, i.e., from 0.03 to 0.06%.

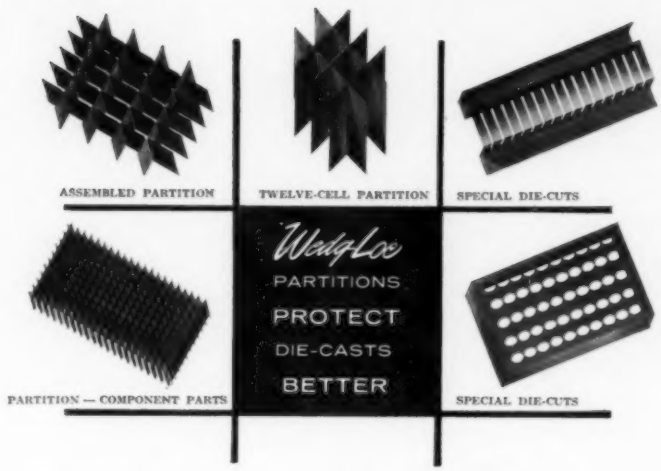
As magnesium approaches the 0.08% max. permitted by the Specification, it will promote sensitivity to cracking while hot and, as a result, many parts being produced may fracture while in the die, prior to ejection. Alloys of yet higher magnesium contents are brittle at room temperature.

COPPER

(0.25% max. and/or 0.75 to 1.25%)

Copper helps to minimize the effects of undesirable impurities and promotes hardness and strength to a relatively small extent. There is strong evidence that the alloys containing more than 1.25% are not as dimensionally stable as those containing less than the permitted maximum. Such high copper contents also promote aging with a serious loss of ductility. Actually, consideration is being given in the ASTM and in the American Die Casting Institute to the elimination of the separate specification for the alloy which contains 0.75 to 1.25% copper. Perhaps, this question will be resolved with the use of one specification alloy having a maximum copper content such as 1.25%, with the individual purchase order or contract to control the element for that specific order (on arrangement between purchaser and supplier).

(Continued on Page 32)



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(Continued from Page 30)

IRON

(0.100% max.)

Iron has no detrimental effect on the properties of zinc alloys in amounts which would be encountered reasonably. It is to be noted that the Specification recognizes that there will be some pickup in melting cycles. Such iron as may exist, over about 0.02%, will tend to concentrate in the surface drosses—therefore, a good skimming practice is important if objectionable inclusions in the die castings are to be avoided. In extreme cases, iron-rich particles which have been entrapped may lead to machining difficulties.

LEAD-CADMIUM-TIN

(0.007, 0.005 and 0.005% max. respectively)

Lead, cadmium and tin are the damaging elements which are commonly encountered as impurities but whose influences are well controlled (so long as held within Specification) by the presence of suitable amounts of magnesium. If they exist in percentages significantly above the Specification limit, they will promote hot shortness in the die and contribute through intergranular corrosion to the loss of dimensional stability and even to cracking in service.

NICKEL-CHROMIUM-SILICON-MANGANESE

(0.02, 0.02, 0.035, and about 0.5% respectively)

Nickel and chromium may be encountered as a result of the practice of remelting plated castings. Silicon and manganese may be introduced through the use of aluminum hardeners containing them. ASTM B86 and B240 have the following to say concerning these elements.

> "Zinc alloy die castings may contain nickel, chromium, silicon, and manganese in amounts up to their solubility (0.02, 0.02, 0.035, and about 0.5 per cent respectively) at the freezing temperature. No harmful effects have ever been noted due to the presence of these elements in these concentrations and, therefore, analyses are not required for these elements."

It should be well understood now and remembered later that the production of excellent looking zinc die castings is no insurance that they will perform well. Furthermore, don't overlook the fact that while the *mechanical properties* of impure materials "as cast" may be on Specification, this fact is no insurance against trouble later, for the injurious influence of impurities may not be evident until a substantial time after the finished parts are in service.

WHY CONTROL IS NECESSARY

It may be helpful to consider the mechanisms which are involved when lead, tin and cadmium are present in amounts at or above Specification limits and without magnesium. It is notable that these elements have the following common characteristics:

a) They are all high density metals with low melting points and low hardness.

b) They have an extremely low solid solubility in zinc.

c) They form very low melting eutectics with zinc which, from the laws of physical metallurgy, having the lowest melting temperature of all alloy phases present, and therefore freezing last, inevitably solidify in the grain boundaries. *(Note:* It is interesting to add that Indium, Thallium, Bismuth and Mercury have the same common characteristics and would act similarly if encountered in zinc die castings. Fortunately, they are not; however, British Specifications for zinc die castings do include Indium and Thallium as elements to be kept out.)

With the system we are now discussing, namely—zinc with aluminum, interlaced with a fine network of grain boundaries of another composition—it is apparent that the situation is ripe for the activation of a large number of electrochemically active cells when the surface is wetted. Observation proves beyond a question of doubt that the main mass of zinc with aluminum is less noble than the grain boundaries when they are rich in impurities. Intercrystalline *corrosion takes place in the zinc immediately adjacent* to the grain boundaries, and in the presence of moisture, with the zinc dissolving in its efforts to protect the more noble lead, tin or cadmium.

The primary role of magnesium, which also joins

(Continued on Page 33)

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(*Continued from Page 32*)

with the eutectics at the grain boundaries in these alloys, is to alter the electropotential relationships between the grain boundaries and the main mass of the die casting.

Inter-crystalline corrosion of zinc die castings does occur when magnesium is lacking or impurities are too high. It is therefore essential to keep lead, tin and cadmium within the Specification limits.

A standard test for susceptibility to this form of deterioration is exposure of the zinc die casting to steam at 95°C (203°F) for ten days. *Figure 1* well illustrates what happens to an impure die casting in this test as compared to the complete ability of a good die casting to withtand it. The impure casting, because of intercrystalline corrosion, snapped sharply after no more than two or three degrees of axial deformation. The good specimen could be bent upon itself. The accelerated test in the steam chest is a convenient means for checking the tendency and for demonstration.

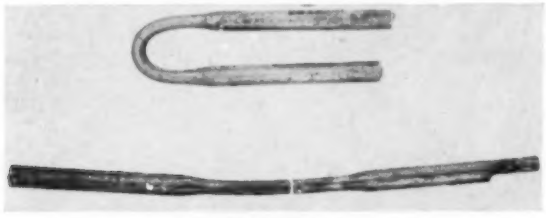

FIGURE 1.

BEND TEST—inpure zinc die casting—above.
BENT TEST—pure zinc die casting—below.
Each after 10 days in steam at 95° C.

HOW CONTROLS CAN BE ARRANGED AND WHAT THEY SHOULD INCLUDE

To our knowledge, there is no U.S. zinc producer who is also a die caster. Certainly, the American Zinc Institute does not operate die-casting machines, and it would be presumptuous of the authors to spell out rigid rules and regulations as to how the die casters shall conduct their day-to-day business of producing good die castings. There are, however, some obvious facts which all should consider. In many cases, they are so obvious that they may have been overlooked. In any event, it should serve a useful purpose to have a list of general recommendations. To a significant extent and, particularly where detailed suggestions are offered, we are quoting recognized authorities.

Adherence to the following general procedures and details will insure the production of zinc alloy die castings which will not be subject to the consequence of inferior service life because of the lack of chemical control.

1) Develop and use only those sources of supply for metals in which you can have permanent confidence. Do not be automatically attracted to "cut price" offers.

2) Keep your plant housekeeping at the highest possible levels of efficiency. The contamination of metal baths can come from so many types of accidents, that it is impossible to define them. Use scrap barrels —mark them plainly. Keep the floors swept. Cover the pots if electricians are working overhead. Take every step you possibly can to insure that nothing gets into the alloy pot either at central melting or at the machines which are not planned to be there.

3) If you use alloy ingot, consult with your sources concerning proper sweetening practices.

4) If you make your own alloy, develop sound practices for blending, and make your cycle time—melting and alloying to casting—as uniform as practical. Arrange for systematic and controlled sweetening practices. Be sure that the ingredients you add are "on Specification." Equip your plant to weigh charges carefully—scales sensitive to ½ oz. for hardener or ¼ lb. for weighing zinc are none too good.

If you don't use induction melting, stirrers with multiblade propellers often help the solution of alloying constituents and insure adequate mixing.

5) When possible, melt centrally and convey uniform molten metal in accordance with your handling facilities to the casting machines. Central melting

(*Continued on Page 34*)

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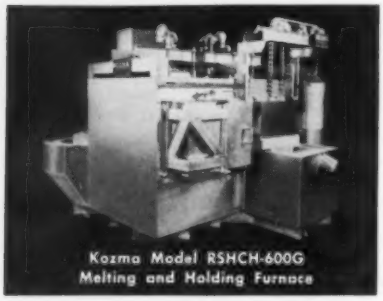

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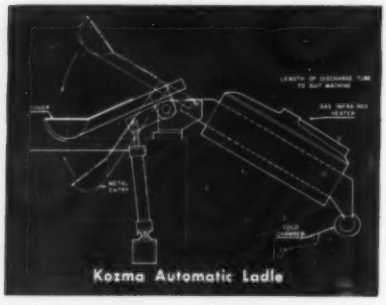

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ALLOY CONTROL

(*Continued from Page* 33)

offers insurance through better opportunity for –

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b) Cleaner metal since it is easier to clean the metal before it is delivered to the machine pots,

c) Less heat and discomfort to the casting operator,

d) Better control of alloy compositions,

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Melting at the casting machine has many real disadvantages. It is practically impossible to maintain uniform metal temperatures. There is always a wide range of temperature throughout a melt particularly at the time of adding cold metal, and control of metal composition is certainly most difficult at these times.

6) The remelting or feedback of plated and unplated casting rejects, gates, flashings, etc. is best accomplished in separate melting facilities and the remelted material should be analyzed before recasting. However, if this is not practical, arrange for such remelt material to be fed into the melting pot at uniform and modest rates rather than in large batches. Such materials, having been through the cycle, have been subjected to both extraordinary opportunities for contamination and magnesium burnout, and to use them in volume without analysis could lead to trouble.

7) Treat fluxing with great respect. Essentially all fluxes contain chlorides. Chlorides and magnesium have an extremely strong affinity for each other and the improper use of fluxes will lead to the reduction of magnesium in the metal to dangerously low levels as a result of the volatization of magnesium chloride. For this phase of your operation, get the best advice you can and check the metal by chemical analysis before the final adoption of any recommendation.

Institute careful and systematic skimming procedures. While it is desirable to stir while alloying, it is undesirable to stir in such fashion or at such times that the impurities floating on the bath's surface would be carried into the melt.

(*Continued on Page* 36)

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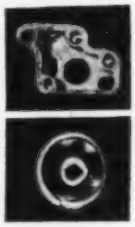

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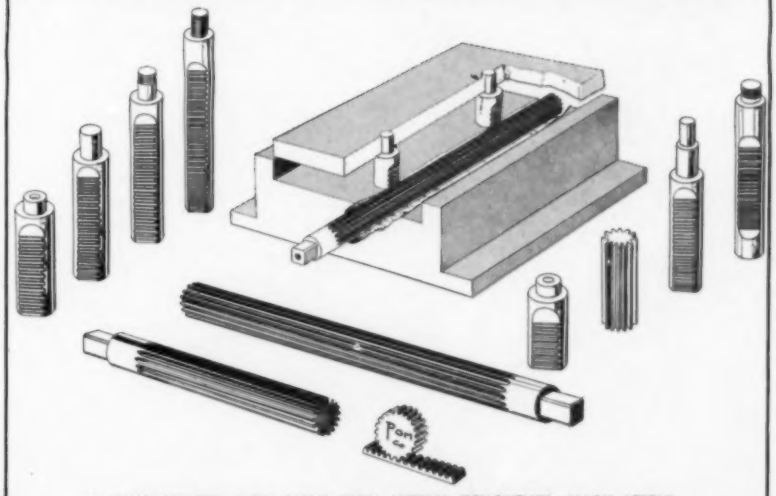

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ALLOY CONTROL

(Continued from Page 34)

8) Determine optimum operating temperatures at both melting pots and machines. Install temperature recorders and require the operation of all baths within specified temperature ranges. Calibrate temperature recorders at intervals. Keep records of the temperatures of the molten metal at the machines for future reference in case of trouble.

9) Make definite arrangements to check the chemical composition of your die castings. Ideally, you would operate your own equipment, such as a spectrograph or Quantometer, either of which can be so cycled as to give analytical results in periods of not over fifteen minutes and which, as a result, offer the opportunity of confirming bath compositions in a practical interval between alloying and casting.

10) It is not enough to rely alone upon certification of analysis as received from your source. There is too much opportunity for things to have gone wrong between the time you receive the raw material and your shipment of finished product.

(Continued inside back cover)

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ALLOY CONTROL

(Continued from Page 36)

11) Instruct your workmen, from sweeper to operator, through the use of formal meetings, in the rudiments of this subject and its importance to the continued success of your plant operation, and repeat such instruction at reasonable intervals. Further, instruct your supervisory personnel to be on the watch for dangerous practices and to take immediate steps when there is any threat to the over-all situation.

12) Insofar as is practical, and certainly of great importance, develop procedure sheets to control each stage of your plant operation. Have a procedure which covers all details and see that it is followed to the letter. Permit no changes or departures without management approval and when changes prove necessary, see that all concerned are informed of the changes and make appropriate alterations on the records and procedure sheets.

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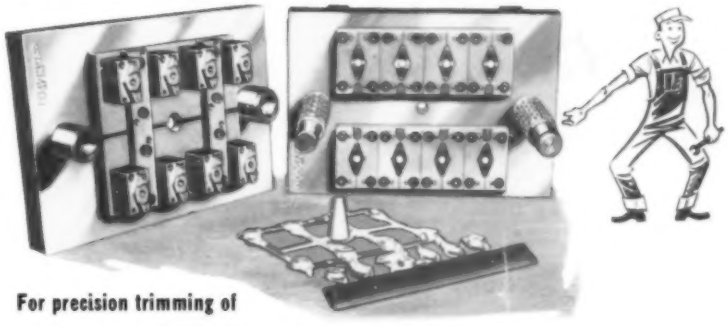

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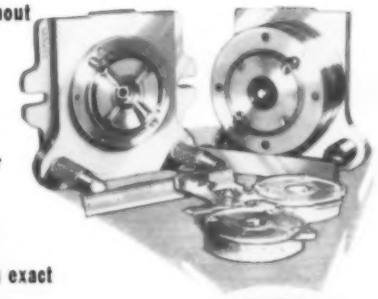

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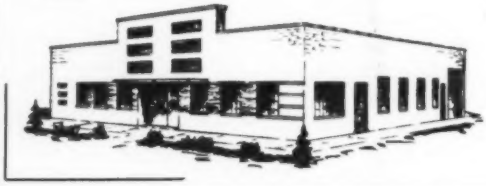

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